STRIP-MINE RECLAMATION LAWS AND REGIONAL COST IMPLICATIONS

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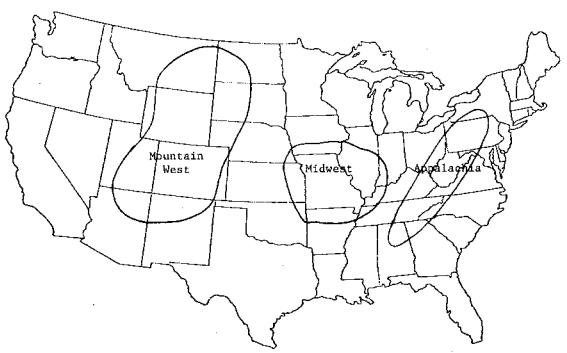
Surface mining, until recent years, concentrated on the recovery of the minerals rather than the recovery of the land. From 1870 to 1930 more than 1.3 billion tons of coal were mined and roughly 250,000 acres were disturbed. In the period 1930-1971, 3,357,000 acres of land were disturbed by surface mining. Approximately 43 percent of this total (1,436,000 acres) was partially or totally reclaimed. Since 1971 most surface-mined land has undergone at least partial reclamation, depending on the state where mining took place. If the nation's estimated 1 trillion tons of coal reserves were developed, approximately 200 million acres would be disturbed by surface mining in the three major coal producing regions (Appalachia, Midwest, and the Mountain West; Figure 1). Evaluation of the economic consequences of reclamation laws therefore is of considerable importance for future energy policies and resource allocation decisions. The purpose of this article is threefold: (1) to outline current reclamation laws, (2) to estimate the cost of reclamation to meet these laws, and (3) to analyze the effects of these costs on different coal producing regions.

FIGURE 1. MAJOR COAL PRODUCING REGIONS IN THE UNITED STATES



RECLAMATION LAWS

State Laws

Early reclamation efforts were undertaken as cost-saving techniques in the Midwest in the 1920s. Coal companies began voluntary reclamation programs to establish quick growth, minimum cost forests on ungraded spoils [2]. Success in West Virginia with reforestation and in Indiana with pasture and row crops provided support for state reclamation laws. In the 1960's, environmental pressures forced the early state laws to be amended and states with no laws to pass legislation.[1] The early tie between private economics and reclamation practices began to diminish as more states moved to adopt reclamation laws that required "back-to-original" practices.[2] Concern in reclamation regulation began to shift from coal companies to landowners and, more importantly, to "third parties."[3] Emphasis was and is being placed on the externalities that result from mining.

FEDERAL LAW

On August 3, 1977, the U. S. Congress passed a comprehensive strip-mine reclamation bill entitled, "Surface Mining Control and Reclamation Act of 1977," Public Law 95-87, which went into effect January 1, 1979. This new law does not void state reclamation laws but requires that, as a minimum, federal standards must be met.

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[1]The old common law maxim, *Cujus est solum, ejus est usque ad collum et ad inferos* (To whomsoever the soil belongs, he owns also the sky and to the depth) [7] was losing its influence on property rights.

[2]Specific court cases adding reinforcement to the changing legislative policies were *Pennsylvania Coal Co. v. Sanderson, Pennsylvania R. Co. v. Sagamore, Straight v. Hover, Day v. Louisville Coal and Coke Co., Jessup and More Paper Co. v. Zeither, West Virginia-Pittsburgh Coal Co. v. Strong, Rockey Bros. Inc. v. Duricka, Department of Forests and Parks v. Georges Creek Coal and Land Co., Durante v. Alba,* and *Pontiac Improvement Co. v. Board of Com'rs,* to name only a few [7].

[3]The courts began to consider the maxim *Sic utere tuo ut alienum non laedas* (Use your own property in such a manner as not to injure that of another) [7].

Some of the major requirements of the bill follow.

1. Reclamation of abandoned mines and mined land is to be financed by a tax on current production (35¢ per ton of coal from surface mining and 10¢ per ton of coal from underground mining, or 10 percent of the coal's value, whichever is less (Section 402 (a)).
2. All resources near mining areas will be protected. Environmental impact statements must be completed (Section 508 (a)).
3. Mine operators must be bonded by an amount sufficient to ensure completion of the reclamation plan, but under no circumstances for less than $10,000 (Section 509 (a)).
4. Standards are included which essentially require "back-to-original" reclamation with exceptions and extensions for certain land classifications (Section 515 (a and b)).

Furthermore, mine operators in filing for a permit must submit a reclamation plan which calls for, among other things, in Section 508 (a) ". . . an estimate of the cost per acre of the reclamation . . . ." [5].

COST OF RECLAMATION

Reclamation costs are a function of several variables, including labor productivity, management, financial markets, technology, environmental regulations, and physical conditions of the land. The efficiency of a particular company's mine manager and/or labor force can be an important cost factor, but it cannot be reliably or easily measured. Physical characteristics of the mine, however, tend to dictate the mining method (technology) and the type of equipment most miners use. Furthermore, a cost function based on physical factors has wider use in estimating reclamation costs for large areas and in areas where no mining has taken place.

The cost of reclamation per ton of mined coal can be represented by the following functions (the *a priori* expected sign is in parentheses).

$$(1)\quad C_t = f(AT_t, HW_t, CS_t, SP_t, CB_t, MM_t)$$

where

C_t = reclamation cost per ton of mined coal in time t
AT_t = annual tonnage of the mine in time t (−)
HW_t = high wall height (overburden depth) in time t (+)
CS_t = number of coal seams in time t (−)
SP_t = average slope (degrees) in time t (+)
CB_t = total coal seam thickness in time t (−)
MM_t = mining method in time t (−).

The annual tonnage (AT_t) of the mine is expected to have a negative impact on reclamation costs. As volume is increased, the need for and use of better and more technically efficient equipment increase. When the mining method (MM_t) changes from draglines to augers or more scrapers and dozers, reclamation costs should increase. With increasing depth of overburden (HW_t), and consequently more cubic yards to move and stockpile, reclamation costs will increase. The number of coal seams (S_t) and seam thickness (CB_t) should be inversely related to costs per ton for reclamation. The gain in tonnage from each seam should outweigh the added cost to remove the overburden of each seam. The steeper the slope (SP_t), the more expensive reclamation operations become. Steeper slopes require more expensive topsoiling operations as well as drainage and erosion controls.

The cost model of equation 1 was fitted with the least squares technique of multiple regression. The statistical model for empirical estimation is of the form:

$$(2)\quad Y = \beta_{ot} + \sum_{i=1}^{6} \beta_{it} X_{it} + \varepsilon_t$$

where

Y = reclamation cost per ton mined in time t
X_{it} = respective variables defined in the cost model, i = 1 . . . 6
ε_t = error term in time t.

The statistical model was fitted with data obtained from a study by Evans and Bitler [1] which involved 20 active mines in Appalachia and the Midwest where "back-to-original" reclamation was performed. Costs were recorded as well as many physical details of the mining process. The estimated equation combines simplicity, significant variables, and overall good fit.[4]

$$(3)\quad C_t = -1.164 + \underset{(.0247)}{.166SP_t} + \underset{(.0201)}{.054HW_t} - \underset{(.2135)}{.401CB_t}$$

$$R^2 = .80$$

[4]The complete theoretical model is hindered by multicollinearity, insignificant t values (.10 level), and complexity of functional form. An abbreviated simpler form of the original model was deemed to have more value as a predictive model. Standard errors of the coefficient are in parentheses.

All β's are significant at the .10 level (t test), and the total equation is significant at the .0001 level (F test).

The fitted equation shows the anticipated positive effect on cost of average slope and overburden depth. As either slope or overburden increases, so does the cost of reclamation. As expected, the thickness of the coal seams has a negative impact on reclamation costs per ton of mined coal. The equation has economic meaning only with certain levels of each independent variable; thus, the intercept term is out of the relevant range. Mining method (MM_t) and average slope (SP_t) have a high simple correlation ($> |.9|$) and thus interchange without significantly altering the final results. This finding adds strength to the argument that physical conditions of the land determine the level and choice of technology in the mining and reclamation process.

REGIONAL COST AND IMPLICATIONS

The slope, overburden depth and quality, and coal seam thickness vary widely among regions in the United States. Consequently, reclamation costs per ton of coal mined differ substantially among regions. Although the estimated equation is based on data only from Appalachia and the Midwest, verification of the model with limited data from the Mountain West shows the equation to be accurate and reliable.

Two scenarios are developed to evaluate the possible effects of "back-to-original" reclamation requirements. The first scenario involves present production patterns and levels. The second scenario allows for regional changes as production is doubled. The national coal model developed by Levins et al. [3] is used to analyze the second scenario. It is a linear multiperiod spatial equilibrium model for the entire United States. The mathematical programming model has an objective function which minimizes total costs subject to the restrictions of washing, transportation, demand and sulfur emissions, capital availability, and certain mining activities. Total costs include extraction, washing, transportation, reclamation, and investments in new mines. Additional details of the model and results can be obtained from [3] and [4].

Table 1 shows the estimated average per ton and aggregate reclamation costs and surface disturbance under current and projected coal production patterns for each region derived by equation 3 adjusted for inflation and the Levins et al. model. A composite average of reclamation costs for each region may create data aggregation problems; however, for comparison the *relative difference between regions* is more important than the absolute costs.

Data from Table 1 and Table 2 show that Appalachia will incur the largest proportion of reclamation costs (64 percent) under "back-to-original" reclamation with present production levels, although only 48 percent of the land is disturbed (a reclamation cost/acres disturbed ration [RC/AD ratio] of 1.33). Therefore for each 1 percent of land disturbed, Appalachia will incur 1.33 percent of the total cost of reclamation. The Midwest has a ratio of .78 and the Mountain West .36. If production patterns do

TABLE 1. REGIONAL RECLAMATION COSTS AND SURFACE ACREAGE DISTURBANCE

	Average reclamation cost per ton of mined coal	Present yearly production levels (Surfaced Mined)	Acres disturbed	Cost of reclamation[a]	Double coal production: Percent of new production[b]	Percent of new production surfaced mined	New annual tonnage[c]	New acres disturbed[d]	Cost of new reclamation	Total cost of reclamation yearly if production doubled
	(1977 dollars)	(million tons)					(million tons)		(dollars)	
Appalachia	6.92 (5.27-9.33)	185.1	83,435	$1,279,034,500 ($15,330/acre)	20	5	32.5	14,663	$224,900,000 ($15,330/acre)	$1,503,934,500
Midwest	6.02 (3.55-7.54)	107.7	71,800	648,763,260 ($9,036/acre)	20	10	65.0	43,333	391,300,000 ($9,036/acre)	1,040,063,260
Mountain	1.01 (.64-1.47)	73.3	18,325	74,062,320 ($4,042/acre)	60	50	325.0	81,250	328,250,000 ($4,042/acre)	402,312,320
		366.1	173,560	$2,001,860,080			422.5	139,246	$944,450,000	$2,946,310,080

[a]This is an estimate based on the "back-to-original" reclamation cost function and should not be construed to mean the present reclamation costs that miners are experiencing.

[b]This is a generalization of results obtained from Levins, R. A., M. D. Boehlje, J. A. Otte, and J. D. Libbin, An Analysis of the National Coal Economy and a Marginal Producing Region, 1976-1990, CARD Report 68, Center for Agriculture and Rural Development, Iowa State University, July 1976 [3].

[c]New annual tonnage represents only the amount of surface production. The double production scenario involves doubling total production (underground and surface), there new annual tonnage (422.5) is not equal to present annual tonnage (366.1). This shows the shift in production patterns resulting from the doubling of coal demand.

[d]This is only an estimate of the pit acres disturbed. A study by Thilenius and Glass [6] suggests that a multiplier of 2.5 can be used to get at total disturbed acres (Pit acres x 2.5 = actual disturbed acres).

TABLE 2. PERCENTAGES AND RATIOS OF RECLAMATION COSTS AND ACREAGE DISTURBANCES

	Percent of Total Land Disturbed	Percent of Total Cost	RC/AD Ratio	Marginal Change In Ratio	Relative Change In Ratio
Appalachia					
Present Production	48	64	1.33	.955	.72
Double Production[a]	10.5	24	2.285		
Total	31	51	1.65		
Midwest					
Present Production	41	32	.78	.54	.69
Double Production	31	41	1.32		
Total	37	35	.95		
Mountain West					
Present Production	11	4	.36	.36	1.00
Double Production	48.5	35	.72		
Total	32	14	.44		

[a]Double production represents the incremental change from present production levels while total production reflects both present and double production.

not change with the advent of "back-to-original" reclamation laws, Appalachia will incur the largest regional impact. Yearly reclamation costs of "back-to-original" laws under present production patterns will be approximately 2 billion dollars for the U.S. Currently surface reclamation costs are approximately .8 −1.2 billion dollars per year.[5]

Present production patterns, however, are unlikely to remain constant over time as production is expanded and reclamation costs increase. The Levins et al., model shows that production will shift away from the higher mining and reclamation cost areas (Appalachia and the Midwest) to the Mountain West region. Table 1 indicates that if production doubles, additional yearly reclamation costs of almost 1 billion dollars ($944,450,000) would be incurred, which represents only about a 50 percent increase from present production pattern cost levels. Surface mine coal production increases about 14 percent, but acreage disturbance decreases by 20 percent mainly because of the shift to the thicker coal seams in the Mountain West.

When production is doubled, the Midwest will have the greatest additional dollar increase in reclamation costs but Appalachia will have the largest RC/AD ratio. Table 2. shows an increase in Appalachia's RC/AD ratio from 1.33 to 2.285, which implies that for a 1 percent disturbance in total land, Appalachia will absorb 2.285 percent of the total United States reclamation costs. The Midwest's RC/AD ratio increases from .78 to 1.32 and the ratio for the Mountain West remains less than one. When both the current and projected production levels are considered in total, Appalachia has the greatest regional reclamation cost. Total yearly reclamation costs in Appalachia to meet "back-to-original" laws will be 1.5 billion dollars (51 percent of U. S. total) for disturbing 98,000 acres (31 percent of U. S. total).

CONCLUSIONS

The cost estimates presented here do not include the federal tax or other indirect costs from Public Law 95-87 and therefore underestimate the actual costs of "back-to-original" reclamation. Also, they do not reflect differences in land productivity; only the amount of overburden enters the equation and not the quality. The relative cost differences among regions therefore should not be construed to imply land productivity differences. They represent differences in depth of overburden, slope, and coal seam thickness.

The cost function can provide miners with an estimate of "back-to-original" reclamation costs to meet Public Law 95-87 requirements until more empirical work becomes available. Also, it can serve as a rough estimate for states and regions for policy considerations. Regional estimates show reclamation costs of 1.2 billion dollars in Appalachia and 2 billion dollars for the U. S. to meet the new Public Law 95-87 standards under current production levels. If the demand for coal or a national energy policy brings forth a doubling of coal production, yearly reclamation costs will approach 3 billion dollars.

Public Law 95-87 should further reduce the competitive position of Appalachia and the Midwest as coal producing regions and improve the competitive position of the Mountain West.

REFERENCES

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[5]This is a rough estimate based on the best secondary data available and confidential sources.

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